Addis Ababa University

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Department of Mechanical Engineering

Engineering Thermodynamics (MEng 2803) ***Work Sheet***

1. The electronic components of a computer are cooled by air flowing through a fan mounted at the inlet of the electronics enclosure. At steady state, air enters at 20^{o}C, 1 atm. For noise control, the velocity of the entering air cannot exceed 1.3 m/s. For temperature control, the temperature of the air at the exit cannot exceed 32^{o}C. The electronic components and fan receive, respectively, 80 W and 18 W of electric power. Determine the smallest fan inlet diameter, in cm, for which the limits on the entering air velocity and exit air temperature are met.

2. As shown in Figure1. 15 kg/s of steam enters a de-superheater operating at steady state at 30bar, 320^{o}C, where it is mixed with liquid water at 25 bar and temperature T_2 to produce saturated vapor at 20 bar. Heat transfer between the device and its surroundings and kinetic and potential energy effects can be neglected. Many
   a. If T_2= 200^{o}C, determine the mass flow rate of liquid, $\dot{m}_2$, in kg/s.
   b. Plot, $\dot{m}_2$ in kg/s, versus T_2 ranging from 20 to 220^{o}C.

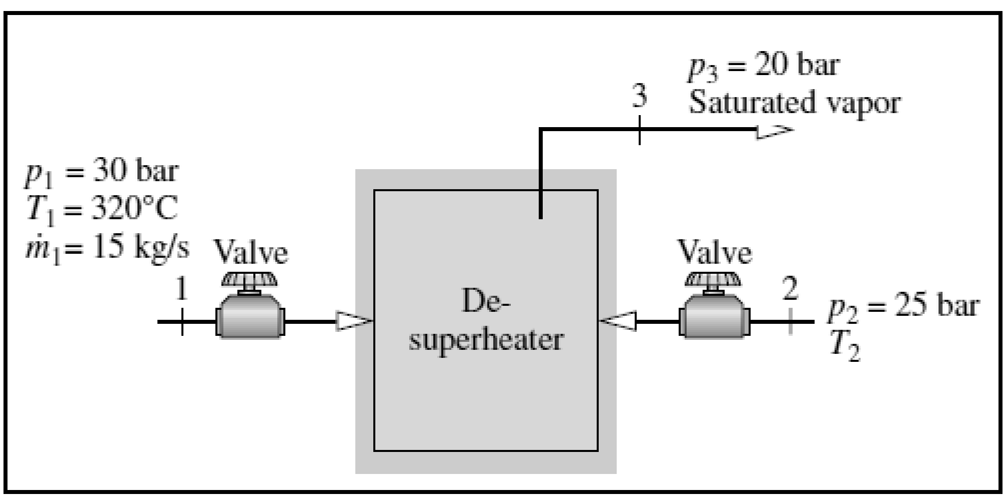


Figure 1

3. A simple steam power plant operates on 20 kg/s of steam, as shown in Figure 2. Neglecting losses in the various components, calculate (a) the boiler heat transfer rate, (b) the turbine power output, (c) the condenser heat transfer rate, (d) the pump power requirement, (e) the velocity in the boiler exit pipe, and (f)the thermal efficiency of the cycle.

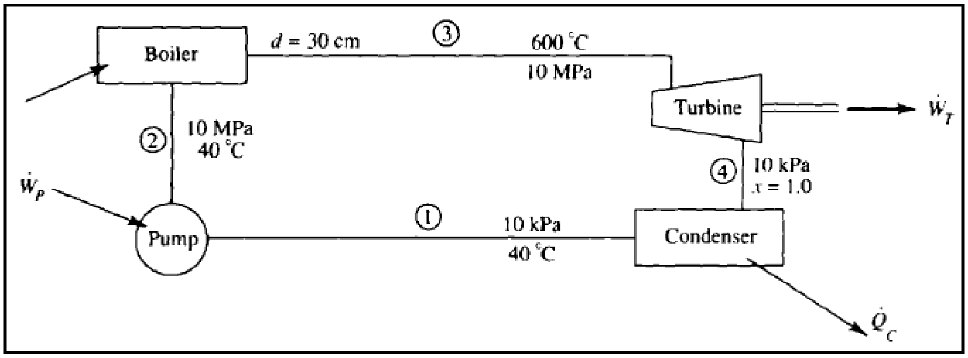


Figure 2

4. An inventor proposes an engine that operates between the 27°C warm surface layer of the ocean and a 10°C layer a few meters down. The inventor claims that the engine produces 100 kW by pumping 20 kg/s of seawater. Is this possible?

5. As shown in Figure 3, water flows from an elevated reservoir through a hydraulic turbine. The pipe diameter is constant, and operation is at steady state. Estimate the minimum mass flow rate, in kg/s, that would be required for a turbine power output of 1 MW. The local acceleration of gravity is 9.8 m/s^2.

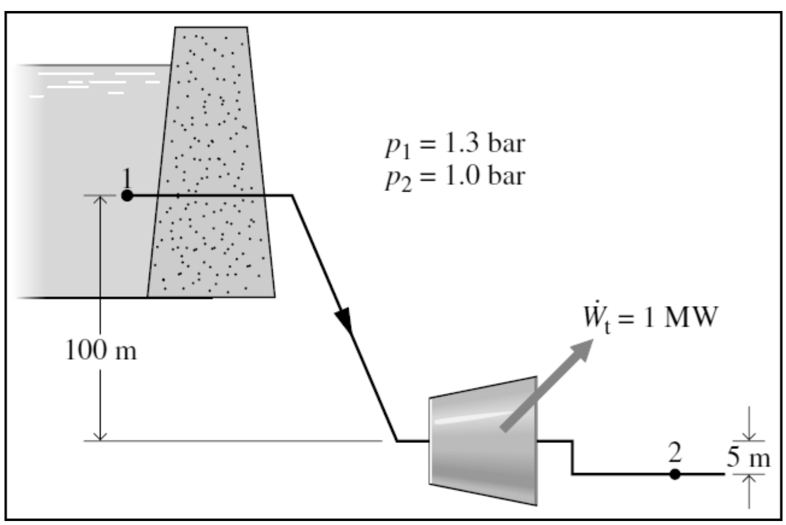


Figure 3

6. An industrial process discharges gaseous combustion products at 478°K, 1 bar with a mass flow rate of 69.78 kg/s. As shown in Fig. 4, a proposed system for utilizing the combustion products combines a heat-recovery steam generator with a turbine. At steady state, combustion products exit the steam generator at 400°K, 1 bar and a separate stream of water enters at 0.275 MPa, 38.9°C with a mass flow rate of 2.079 kg/s. At the exit of the turbine, the pressure is 0.07 bars and the quality is 93%. Heat transfer from the outer surfaces of the steam generator and turbine can be ignored, as can the changes in kinetic and potential energies of the flowing streams. There is no significant pressure drop for the water flowing through the steam generator. The combustion products can be modeled as air as an ideal gas.
    a. Determine the power developed by the turbine, in kJ/s.
    b. Determine the turbine inlet temperature, in °C.
    c.

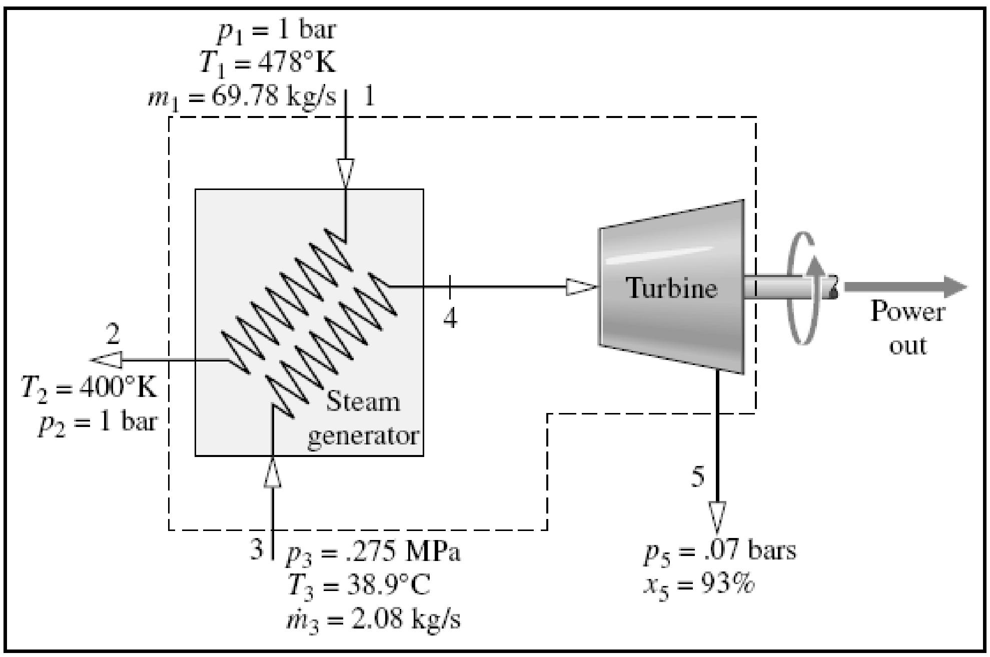
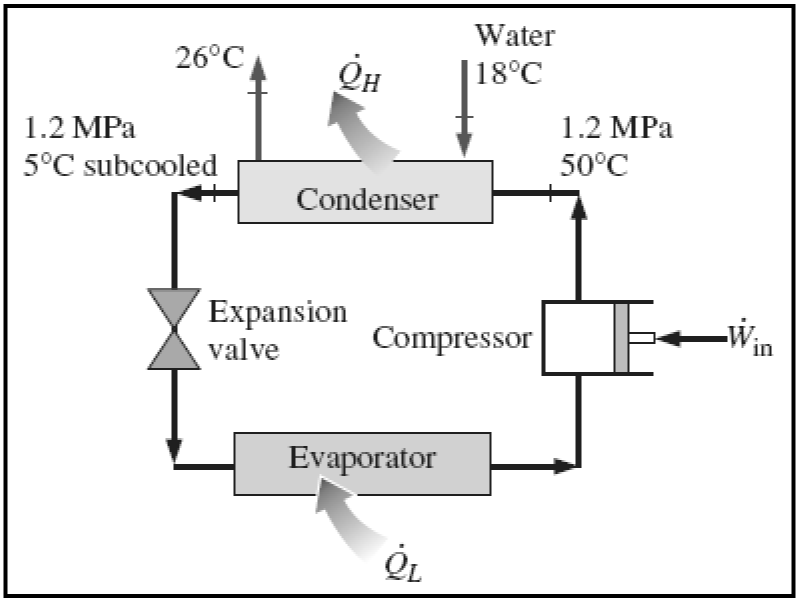


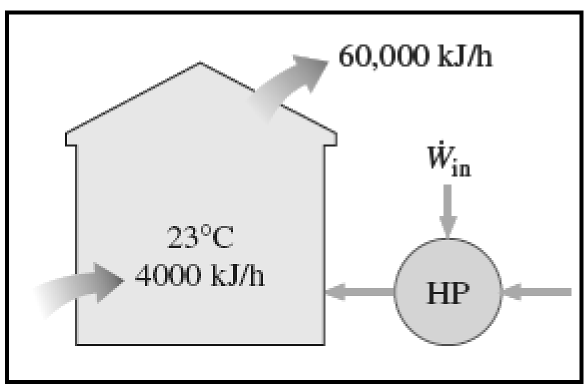
Figure 4

7. A commercial refrigerator with refrigerant-134a as the working fluid is used to keep the refrigerated space at -35°C by rejecting waste heat to cooling water that enters the condenser at 18°C at a rate of 0.25 kg/s and leaves at 26°C. The refrigerant enters the condenser at 1.2 MPa and 50°C and leaves at the same pressure subcooled by 5°C. If the

compressor consumes 3.3 kW of power, determine (a) the mass flow rate of the refrigerant, (b) the refrigeration load, (c) the COP, and (d) the minimum power input to the compressor for the same refrigeration load.

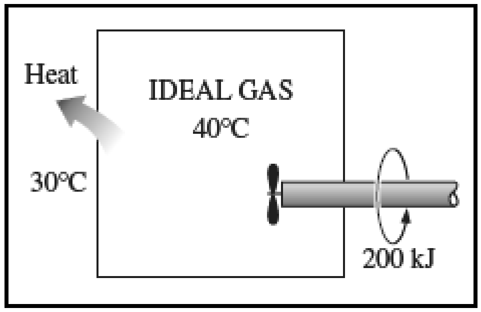


8. A heat pump is used to maintain a house at a constant temperature of 23°C. The house is losing heat to the outside air through the walls and the windows at a rate of 60,000 kJ/h while the energy generated within the house from people, lights, and appliances amounts to 4000 kJ/h. For a COP of 2.5, determine the required power input to the heat pump.



9. A well-insulated rigid tank contains 2 kg of a saturated liquid–vapor mixture of water at 100 kPa. Initially, three-quarters of the mass is in the liquid phase. An electric resistance heater placed in the tank is now turned on and kept on until all the liquid in the tank is vaporized. Determine the entropy change of the steam during this process.

10. A rigid tank contains an ideal gas at 40°C that is being stirred by a paddle wheel. The paddle wheel does 200 kJ of work on the ideal gas. It is observed that the temperature of the ideal gas remains constant during this process as a result of heat transfer between the system and the surroundings at 30°C. Determine the entropy change of the ideal gas.



11. A piston/cylinder contains 3 kg of water at 500 kPa, 600◦C. The piston has a cross-sectional area of 0.1 m2 and is restrained by a linear spring with spring constant 10 kN/m. The setup is allowed to cool down to room temperature due to heat transfer to the room at 20◦C. Calculate the total (water and surroundings) change in entropy for the process.